RESONANCE ABSORPTION OF SLOW NEUTRONS IN "EVEN — EVEN" NUCLEI

BY

ANDREW WILLIAM SUNYAR

A.B., Albion College, 1942
M.S., University of Illinois, 1944

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSICS
IN THE GRADUATE COLLEGE OF THE
UNIVERSITY OF ILLINOIS, 1949

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ACKNOWLEDGMENT

I am happy to be able to acknowledge my indebtedness to Professor M. Goldhaber for his constant guidance and advice during the course of these experiments. His judgment and knowledge have been of great help in interpreting these data.

I wish to thank Mr. Stuart P. Lloyd for the evaluation of a integral.

The assistance of Mr. Arthur Colbey, glassblower, and of Mr. Harold Stoner, mechanician, is appreciated.

R. UNIV. BIBLIOTHEEK LEIDEN

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Present experimental evidence seems to indicate that there is an essential difference in the slow neutron capture characteristics of "even-even" nuclei as compared to "odd-even" nuclei. Only two stable capturing nuclei of the "even-even" type have previously been known to exhibit resonance capture of slow neutrons. These capturing isotopes are $_{46}Pd^{108}$ and $_{74}W^{186}$.

A group of 17 "even-even" nuclei whose atomic numbers range from 28 to 82 have been examined for evidences of slow neutron resonances. Activation was induced by exposure to the neutrons from a 441 mg. radium-alpha-beryllium source imbedded in paraffin. A cadmium sheet was used to eliminate thermal neutrons from the flux. Absolute resonance integrals have been obtained for the activities investigated. The resonance level in gold at 4.8 ev. has been adopted as a standard. Breit-Wigner constants have been assumed for this level, and it is assumed that the neutron flux is proportional to 1/E. The resonance integrals obtained are as a rule smaller than resonance integrals for "odd-even" capturing nuclei by a factor of the order of 100. Exceptions occur in the case of the capturing isotopes $_{62}Sm^{152}$ (46 hour) and $_{78}Pt^{198}$ (31 minute). Breit-Wigner constants are obtained for the samarium and platinum resonance levels by assuming values for the widths of the gold resonance level. In the case of samarium the neutron width is comparable to the radiation width.

If one assumes that the neutron flux varies as 1/E, the resonance integral is proportional to the neutron width reduced to 1 ev., and inversely proportional to the 3/2 power of the resonance energy. Experimental evidence indicates that for the four resonance levels of "even-even" nuclei now known, the reduced neutron width is on the average comparable to

the reduced neutron widths for the resonance levels of "odd-even" capturing nuclei. Hence, it is probable that resonance energies for the capture levels of "even-even" nuclei are on the average larger by a factor of the order of 20 than resonance energies for the capture levels of "odd-even" nuclei.

The natural line width for the resonance level in Pd^{108} which leads to the 13 hour activity has been determined by a method which utilizes the Doppler effect. When the thermal motion of the capturing nucleus is considered, the effective capture cross section is no longer given by the Breit-Wigner one level formula. The cross section is reduced at the resonance maximum and increased in the wings of the resonance. The magnitude of this effect depends upon the ratio of the natural line width to the Doppler width. A thick "self-absorber" was used to remove from the neutron flux those neutrons whose energies lie within a few half-widths of the resonance maximum. A thin detector was exposed to this altered neutron flux and the induced detector activity measured for two detector temperatures. The activity increases when the temperature is increased. By comparing the measured activity ratio with the activity ratio to be expected for various values of the natural width a value of 0.20 ev. was obtained for the total natural width of the palladium resonance level. This value is subject to the assumptions that the neutron flux is inversely proportional to the energy and that the cross section at exact resonance is equal to $40{,}000 \times 10^{-24}$ cm.^{2}

The 1.5 minute activity induced by slow neutron capture

in iridium has been investigated. Absorption of the activating neutrons by cadmium shows that the capture level which gives rise to the major portion of this activity is located at 0.65 ev. This capture level has been shown by other workers to lead to the 70 day activity in iridium, which has been assigned with certainty to the isotope Ir^{192}. It is concluded that the 1.5 minute activity is to be associated with a metastable state of Ir^{192}. An absolute resonance integral for the 0.65 ev. capture level is given.

VITA

Andrew William Sunyar was born September 9, 1920, in Henderson, Michigan. He attended the elementary school at Henderson, Michigan, and Owosso High School at Owosso, Michigan. In 1942 he received the Bachelor of Arts degree from Albion College, Albion, Michigan. He attended the University of Illinois from 1942 to 1944 and held a teaching assistantship during this period. In 1944 he received the Master of Science degree from the University of Illinois. He served in the navy from 1944 to 1946 as a maintenance officer for airborne radar and radio equipment. After his release to inactive duty he returned to the University of Illinois, where he has been a research assistant since July, 1946. He is a member of the American Physical Society and of Sigma Xi.

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